

FACT SHEET

Proposed Issuance of Underground Injection Control (UIC) Area Permit AK-1I002-A
for the Construction and Operation of Class I Non-Hazardous Industrial Waste Injection Wells
at the Northstar Oil and Gas Unit on the North Slope of Alaska

U.S. Environmental Protection Agency, Region 10
Underground Injection Control (UIC) Program
Ground Water Protection Unit, OW-137
1200 Sixth Avenue
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Background

BP Exploration (Alaska), Inc., known as BPXA, submitted an Underground Injection Control (UIC) permit application for the construction and operation of one or two Class I non-hazardous industrial waste injection wells at the Northstar Unit, located on a gravel island six miles offshore in the Beaufort Sea about 15 miles northwest of the main Prudhoe Bay field complex. The initial application and supplemental information was submitted in June of 1996, and a final revised application was submitted August 28, 1997. Also, BPXA presented fracture slurry injection information relevant to the Northstar permit application to UIC program representatives from EPA Headquarters and Regions 3, 4, 5, 6, 8, 9, and 10 at an all-day technical meeting held in Seattle on February 5, 1997.

EPA prepared a draft UIC permit and associated aquifer exemption and sought public comment in 1998 as part of the Draft Environmental Impact Statement (DEIS) issued for the proposed Northstar project by the Corps of Engineers. Comments on the draft UIC permit were received from BPXA and Greenpeace. No public comments were submitted about the associated aquifer exemption. After reviewing the comments and responding to them through the DEIS process, EPA was prepared to issue a Class I non-hazardous waste injection well permit and associated aquifer exemption to BPXA in 1998. However, the Northstar project was delayed, and drilling of the injection well is now scheduled for the winter of 2000.

Some time after the 1998 public comment period had ended, peer reviewers from other EPA Regions and Headquarters suggested that additional information be obtained and analyzed to

determine if, in fact, the aquifers beneath the Northstar Unit area might all be too naturally saline to qualify as USDWs. It was pointed out that there would be no reason to issue the proposed aquifer exemption if that were the case. BPXA provided EPA with additional information about the salinity of underground formation waters on October 5, 1999; November 5, 1999; and December 15, 1999. On April 10, 2000, BPXA submitted a revised Appendix F to the 1996 permit application. The slightly revised permit application documents a surface locational change and associated changes to the directional profile, requests setting surface casing at about 3000 feet because of potentially gas-bearing horizons below 3500 feet, requests that the cement behind the intermediate string of casing extend about 500 feet above the surface casing shoe rather than to the surface, and includes a more general description of how the well will eventually be plugged and abandoned.

EPA has reviewed this information and concluded that there are most likely not any USDWs beneath the Northstar Unit area, and therefore no longer intends to issue the proposed aquifer exemption. A full explanation of why EPA now thinks that there are no aquifers in the area which qualify as USDWs is found later in this fact sheet. And since this information was obtained and analyzed after the 1998 public comment period had ended, EPA is again seeking public comment. EPA has reviewed the revised Appendix F, also submitted after the 1998 public comment period had ended, considers the requested changes acceptable, and has slightly altered the draft permit from that which received public comment during 1998.

Public Comment

Peer review comments were sought in developing the proposed permit and this fact sheet from the Alaska Department of Environmental Conservation (ADEC) and the Alaska Oil and Gas Conservation Commission (AOGCC). EPA is now requesting public comment on the draft permit. Persons wishing to comment on the proposed permit may do so by July 26, 2000. EPA will issue no separate public notice and may finalize the permit as drafted if no substantive comments are received by the close of the public comment period.

Regulatory Framework

The Underground Injection Control (UIC) program is authorized by Part C of the Safe Drinking Water Act for the principal purpose of protecting Underground Sources of Drinking Water (USDWs) from pollution by injection through wells. The UIC regulations broadly define USDWs (see 40 CFR 144.3) as any aquifer capable of supplying a public water system with water of less than 10,000 milligrams per liter (mg/L) total dissolved solids (TDS). If injection does not occur above, into, or through a USDW, then less stringent injection well permit conditions may be imposed than would otherwise be required (see 40 CFR 144.16).

Primary responsibility for regulation of injection wells through the UIC program is split in Alaska between EPA and the Alaska Oil and Gas Conservation Commission (AOGCC). The AOGCC regulates Class II injection wells, which are defined as those wells used 1) to dispose of waste fluids brought to the surface from oil and gas production operations, 2) for enhanced recovery of oil and gas, or 3) for storage of hydrocarbons which are liquid at standard

temperature and pressure (see 40 CFR 144.6). EPA directly regulates the other four classes of injection wells. The UIC regulations allow Class II fluids to be disposed of into Class I or II injection wells. Class I fluids, however, may not be injected into Class II wells.

BPXA expects that almost the entire waste stream at Northstar would be eligible for injection into Class II disposal wells. The remainder would be domestic wastewater and other fluids eligible for disposal into Class I non-hazardous waste industrial injection wells. Therefore, by obtaining a Class I non-hazardous waste injection well permit from EPA, BPXA could dispose of the entire non-hazardous waste stream at Northstar into the same one or two injection wells.

As noted above and described further below, those aquifers beneath the Northstar Unit area are too naturally saline to be considered as USDWs. Under these circumstances, the Director may authorize injection with less stringent requirements than would otherwise be required (see 40 CFR 144.16). EPA intends to grant several waivers requested by BPX, which are described under the Geologic Setting and Injection Issues portion of this Fact Sheet.

EPA Permit and General Project Overview

EPA's 10-year term permit would allow BPXA to inject non-hazardous waste fluids such as, but not limited to, produced oil reservoir brine, production camp waste water, production well workover fluids, drilling muds, and drill cuttings through either one or two injection wells. The permit would allow BPXA to inject all of the non-hazardous waste fluids generated at Northstar. This plan to blend and inject all non-hazardous waste fluids is favored by EPA since it would minimize discharge to the Beaufort Sea, and reduce the need to transport waste from the isolated unit for off-site treatment or disposal.

Some solid waste materials (such as frac sand and drill cuttings) would be pulverized onsite and mixed with wastewater to be injected as a thin slurry. This would require injection pressures great enough to fracture the receiving formation. The permit would limit most slurry injection to the deepest permitted injection zone, below about 5000 feet, and prohibits the initiation or propagation of existing fractures within the upper shale confining zone, whose base is about 3300 feet below the surface.

The proposed permit initially limits injection to the naturally saline Prince Creek/Ugnu Formation operation, when most fracture slurry injection is expected to occur. Later, as the need for fracture slurry injection decreases, the draft permit would also allow injection into part of the lower Sagavanirktok Formation, at depths below about 4000 feet. EPA has determined that the proposed injection intervals and overlying aquifers are too naturally saline to be considered as underground sources of drinking water (USDWs) as defined by the UIC regulations.

The Northstar Unit is located about six miles offshore at Prudhoe Bay on a gravel island. BPXA has requested the option to drill up to two Class I non-hazardous industrial waste injection wells from this island. The permit application notes that although a second well might not be necessary, having the option to immediately drill and complete a second injection well will provide operational flexibility and redundancy in the event of a mechanical failure of the primary

well.

BPXA estimates that over 98 percent of the injection waste stream at Northstar will consist of produced water (oil reservoir brine), which will not require any grinding before injection. Most of the remaining waste stream will also be in liquid form. That portion of the anticipated waste stream that is solid will be pulverized in an onsite ball mill and mixed with liquid waste to form a thin slurry. In order to prevent formation plugging, injection pressures will need to be high enough to propagate fractures within the injection zone. The estimated volumes of waste to be injected during the anticipated 20-year life of the Northstar project are as follows.

Volume in Barrels (42 U.S. gallons)

No Grinding Needed

Produced water (oil reservoir brine)	118,500,000
Stormwater (from on-site rain and snowmelt)	182,500

Little or No Grinding Needed

Camp sewage and gray water	600,000
Well workover fluids	400,000
Drilling muds and associated fluids	360,000
Industrial non-hazardous waste fluids	40,000

Grinding Needed

Rock cuttings (and flush water), frac sand, vessel sludge/sand, etc.	140,000
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Total Estimated Volume	120,222,500
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The amount of fracture slurry injection (conducted at greater than formation fracture pressure) is expected to decline markedly after two years because drill cuttings, drilling mud, and frac sand will be generated predominately during the initial drilling and well completion phase of field production. During the first two years of field development, the average fracture slurry injection rate is expected to be about 28,000 Barrels (1,176,000 gallons) per month. A maximum fracture slurry injection rate of 65,000 Barrels (2,730,000 gallons) per month is expected when disposing of backlogs which might develop because of plant upsets, scheduled shutdowns, well treatments, workovers, etc., which may occur during the first two years of the project.

The amount of produced water (oil reservoir brine) is expected to reach about 16,000 Barrels (672,000 gallons) per day after the first few years, and continue at about that rate for the balance of the 20 year life of the project.

In light of the anticipated types and volumes of fluid to be injected over time, EPA is proposing that the permit authorize injection in two phases. During the first two years of the permit, when fracture slurry injection would predominate, BPXA would be authorized to inject only into the lower zone, below the TMBK marker bed, which is at about 5000 feet below the land surface. Thereafter, and for the balance of the permit term, the permittee would be authorized to inject into both the lower and the upper intervals, which includes permeable zones of the lower Sagavanirktok Formation up to the SV2 marker bed (at about 4000 feet below the surface).

BPXA has not applied for a hazardous waste injection well permit. Therefore, any listed hazardous wastes would need to be collected, stored, and transported to a RCRA-approved hazardous waste treatment or disposal facility. Those wastes which are hazardous only because of a characteristic (such as ignitability, corrosivity, toxicity, etc.) may be treated to remove that characteristic and then injected as a Class I non-hazardous waste fluid. The only radioactive substance which may be injected under the proposed permit is naturally occurring radioactive material (NORM) from sludge or pipe scale (a mineral precipitate formed during production), which can be injected into either Class II or Class I non-hazardous waste injection wells.

Geologic Setting and Injection Issues

The geologic setting at the Northstar Unit is favorable for waste disposal via injection wells. The stratigraphic sequence and lithology are highly correlative with the formations found at Prudhoe Bay, where hundreds of Class II injection wells have operated successfully for almost two decades. These formations dip to the east-northeast at 1 to 2 degrees, and there are no faults within the injection, arresting, or confining zones.

When reviewing the application in 1998, EPA thought that some aquifers within or above the injection intervals might marginally meet the definition of an Underground Source of Drinking Water (USDW). A USDW is defined as an aquifer which is currently serving as a source of potable water or which, by virtue of its potential productivity and natural water quality (i.e., less than 10,000 milligrams per liter of total dissolved solids or TDS), could serve as a public water supply. In the case of Northstar, no formation water samples were taken. Instead, BPXA submitted water quality estimates calculated from geophysical borehole log readings, using typical assumptions and standard empirical formulas. These estimates suggested to EPA that the aquifers of concern, found beneath the permafrost from about 1500 to 7000 feet in depth, contain water ranging from about 12,000 to 40,000 mg/L TDS. BPXA acknowledged some degree of uncertainty associated with these estimates, and requested that EPA exempt the aquifers beneath Northstar from protection as USDWs.

The Federal regulations at 40 CFR 144.7 and 146.4 allow an aquifer to be exempted from protection as a USDW provided it meets several criteria. These criteria were listed in the Fact Sheet of May 1, 1998 which described why EPA thought the criteria had been satisfied. EPA received no public comments which objected to the proposed aquifer exemption in conjunction with the draft permit. However, some other EPA Regional Offices suggested, after the close of the public comment period, that additional information be obtained and analyzed in an effort to

better determine whether or not any of the aquifers would qualify as USDWs.

In response to EPA's request for further information, BPXA submitted EPA with a list of detailed formation water quality estimates calculated for the clean sand intervals encountered in six Northstar area wells. For each of these intervals, the measured formation temperature, electrical resistivity, and density were used to calculate porosity and total salinity. The salinity estimates were calculated using a general form of the Archie equation, which is shown below:

$R_w = R_t (N \text{ raised to the } m \text{ power})$ where:

R_w = Resistivity of the formation water;

R_t = True resistivity of the formation, both rock and water;

N = Porosity of the formation; and

m = Cementation factor.

R_w is calculated and converted to the corresponding salinity, based upon the formation temperature. The calculated salinity is conservatively assumed to be equivalent to the TDS concentration of the formation water.

R_t is the measured deep induction log resistivity.

Porosity (N) is calculated from the measured density of the formation, assuming that the formation matrix of a clean sand is almost entirely composed of quartz grains.

The cementation factor (m) varies by rock type and typically ranges from 1.5 to 1.8 for permeable sand intervals of the Sagavanirktok Formation.

BPXA submitted tables for each permeable sand interval which listed the formation thickness, resistivity, porosity, and temperature as determined from geophysical borehole logs, and the corresponding calculated salinity using 1.4, 1.6, and 1.8 as values for the cementation factor (m). The calculated formation water salinity is highest where $m=1.8$, intermediate where $m=1.6$ and lowest where $m=1.4$. BPXA also submitted back-calculated " m " values from sand intervals within the Sagavanirktok Formation at the Prudhoe Bay field where water samples had been collected and analyzed. These " m " values range from 1.54 to 1.77.

All of the calculated salinity levels in each of the five nearby wells are above the 10,000 mg/L threshold even when $m=1.4$, which is probably lower than its actual range of values. These results are summarized below.

Calculated salinity levels (mg/L of Na^+ and Cl^-) where $m=1.4$

<u>Well Name</u>	<u># of Intervals</u>	<u>High</u>	<u>Median</u>	<u>Low</u>
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Northstar 1	35	48,832	22,572	11,451
Seal-A-01	35	45,051	24,694	14,300
Seal-A-02	35	43,518	19,235	13,242
Seal-A-03	41	48,880	23,999	13,922
Seal-A-04	44	47,949	23,182	13,343

Since the proposed well(s) would not inject below a USDW, EPA may allow less stringent requirements for area of review, construction, mechanical integrity, operation, monitoring, and reporting than would otherwise be required by the UIC regulations (see 40 CFR 144.16). At Northstar, EPA intends to only relax some of the operating and monitoring requirements, as described below.

Compatibility of Formation and Intestate: Based upon the applicability of past inject ability studies and injection practices at Prudhoe Bay, EPA intends to waive the requirements of 40 CFR 146.12(e) and 146.14(a) which require sampling and characterization of formation fluids and matrix in order to determine whether or not they are compatible with the proposed intestate.

Injection Zone Fracturing: Class I injection wells are prohibited from injecting at pressures that would initiate new fractures or propagate existing fractures within the injection zone. The draft permit would waive this prohibition, and would instead allow hydraulic fracturing so long as new fractures are not initiated nor existing ones propagated within the upper confining zone. Fracture slurry injection will be initially limited to the Ugnu Formation, below about 5000 feet in depth and later, as needed, injection would also be permitted into the lower Sagavanirktok Formation up to the SV2 marker bed (about 4000 feet deep).

Ambient Monitoring Above the Confining Zone: EPA intends to waive the requirement to monitor the strata overlying the confining zone for fluid movement (see 40 CFR 146.134). The principal purpose of this requirement is to protect overlying USDWs. However, the aquifers at the Northstar Unit are too naturally saline to qualify as USDWs.

Summary of Proposed Action and Permit Conditions

EPA has primary enforcement authority in Alaska for the 1422 portion of the UIC program (authorized by Part C of the Safe Drinking Water Act), which includes the regulation of Class I injection wells. Class I wells are used to inject waste fluids for safe disposal beneath any existing USDWs. EPA proposes to grant an area permit to BPXA for up to two Class I non-hazardous waste injection wells at the Northstar Unit. EPA considered all of the available disposal options, and concludes that underground injection is the best disposal method for the non-hazardous liquid and solid wastes to be generated at the Northstar Unit during the project's anticipated 20-year lifetime.

Based upon all available information, EPA has determined that there are no USDWs beneath the Northstar Unit area, and intends to grant BPXA a waiver of the UIC program regulation which

prohibits hydraulic fracturing of the injection zone (40 CFR 146.13). This waiver will enable the injection of a slurry composed of non-hazardous waste liquid and pulverized non-hazardous solid wastes (drill cuttings, frac sand, etc.) characteristic of oil drilling and production operations, and is authorized by the UIC program regulations under 40 CFR 144.16a.

The draft permit contains general legal provisions common to EPA permits, specific technical requirements that apply to all Class I injection wells, and particular technical requirements for the proposed injection operations at Northstar. The project specific permit conditions would initially restrict injection to the lower of two selected stratigraphic intervals during the time when most fracture slurry injection is to be needed. Additionally, injection pressure would be limited for the duration of the 10-year term permit.

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